

REMARKS

Claims 76-79 and newly added claims 80-92 are currently pending in the present patent application, with claims 47 and 48 and having been canceled. In an Office Action mailed October 8, 2002 the Examiner rejected claims 76-79 and claim 47 under the second paragraph of 35 U.S.C. § 112. The claims have been amended to correct any such deficiencies, and now satisfy Section 112. None of these amendments narrows the scopes of the pending claims. The amendments also reflect the election of the invention to be prosecuted in the present application, namely the invention including the species diborane, phosphine, HCl, and boron trichloride.

In the Office Action, the Examiner rejected claims 76-79 under 35 U.S.C. § 102(e) as being anticipated by United States Patent No. 6,162,715 to Mak *et al.* ("Mak"). Before discussing the pending claims in view of the Mak reference, the disclosed embodiments of the present invention will now be discussed in comparison to the Mak reference in order to help the Examiner appreciate certain distinctions between the pending claims and the subject matter of the Mak reference. Specific distinctions between the pending claims and the applied reference will be discussed after the discussion of the disclosed embodiment and the applied reference. This discussion of the differences between the disclosed embodiment and applied reference does not define the scope or interpretation of any of the claims.

Applicant's invention exposes a conductive layer to an oxygen-inhibiting plasma or other gas prior to the formation of the another layer or layers on the conductive layer to substantially reduce the association of oxygen with the conductive layer during formation of the other layer or layers. By reducing the amount of oxygen associated with the conductive layer, the electrical characteristics of a semiconductor device including the conductive layer are improved, as will be discussed in more detail below with reference to the disclosed embodiments of the invention. One embodiment of the present invention is discussed with reference to Figures 7-10 in which an interposing layer 52 such as a tungsten nitride layer 52 is formed between a conductive plug 46 formed in a via 44 and a conductive line material 48 formed in a trench or container 50. The tungsten nitride layer 52 enhances the electrical contact between the line material 48 and the plug 46, promotes adhesion of the line material within the container 50, and prevents or slows the diffusion of materials across the tungsten nitride layer boundary, or serves some other purpose. The tungsten nitride layer 52 may associate with oxygen after it is formed

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and subsequent thermal processes may result in the formation of an oxide layer 54 formed between the tungsten nitride layer 52 and the line material 48 as shown in Figure 8. Because the oxide layer 54 is an insulator, this layer will adversely affect the electrical connection between the line material 48 and the plug 46.

By exposing the tungsten nitride layer 52 to an oxygen-inhibiting agent or a reducing atmosphere prior to formation of the line material 48, the thickness of the oxide layer 54 is reduced to a thickness of less than 10 angstroms or entirely eliminated as illustrated respectively in Figures 9 and 10. As described in the specification, the tungsten nitride layer 52 or other conductive layer may be treated with gases such as diborane B_2H_6 , PH_3 , CH_3SiH_3 , $(CH_3)_3Si-Si(CH_3)_3$, HMDS, CF_4 , CHF_3 , HCL , BCl_3 , and silane SiH_4 , and any combinations of these gases, as described on page 7, lines 25-30, page 8, lines 1-16, and page 9, lines 1-12. Even if the tungsten nitride layer 52 is exposed to oxygen, the layer may thereafter be exposed to a reducing atmosphere, such as silane gas SiH_4 , prior to formation of the line material 48 to thereby reduce the oxygen content of the tungsten nitride layer 52 and reduce the thickness of or eliminate any silicon dioxide layer 54 thereafter formed. A reducing atmosphere removes oxygen from a material, which is said to have been reduced, in contrast to oxidation in which a material associates with oxygen, as understood by those skilled in the art.

The Mak patent discloses a method of forming a gate electrode connection structure by depositing a tungsten nitride barrier layer 8 on a polysilicon electrode 4 and thereafter forming a tungsten layer 9 on the tungsten nitride barrier layer as illustrated in Figures 1A-E. The purpose of the Mak patent is: 1) to eliminate contaminant particles typically formed during formation of the tungsten nitride barrier layer 8, because such particles may become attached to a deposition chamber's interior and subsequently flake off to contaminate a wafer being processed within the chamber; and 2) to improve the adhesion of tungsten nitride layers to the substrate upon which such layers are deposited. Mak's solution is to pretreat the polysilicon electrode 4 with a plasma as illustrated in Figure 1B, which improves adhesion of the subsequently formed tungsten nitride diffusion barrier layer 8 as shown in Figure 1C. The tungsten layer 9 may be deposited by flowing a tungsten containing gas such as WF_6 and a hydride of an element of group III or V, such as diborane. The diborane reacts with the WF_6 on

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a heated wafer to form BF_3 , removing fluorine from the reaction and eliminating solid byproducts including fluorine that may contaminate the wafer.

Note that the Mak patent discusses the exposure of the tungsten nitride barrier layer 8 to oxygen, and indicates that such exposure may cause a native oxide to form on the layer which undesirably increases the resistivity of the layer. See column 5, lines 41-56. The solution proposed by the Mak patent is to form the tungsten nitride barrier layer 8 and tungsten layer 9 *in situ*, eliminating the need to expose the tungsten nitride barrier layer to environmental contaminants such as oxygen that may be encountered when transferring the wafer from a first chamber to a second chamber. There is no discussion or suggestion in Mak of exposing the tungsten nitride barrier layer 8 to one of the materials in the group phosphine, HCL , and boron trichloride to inhibit an ability of the layer to associate with oxygen. With regard to the use of diborane in Mac, the tungsten nitride barrier layer 8 is not exposed to diborane to passivate this layer, but the diborane instead, as previously described, merely serves as a source of boron to remove fluorine from the reaction that takes place to form the tungsten layer 9.

Amended claim 76 recites a method of treating a wafer that includes depositing a first conductive layer onto the wafer, exposing the wafer *in situ* to a reducing environment, depositing a second conductive layer; and exposing the wafer to a material selected from the group consisting of phosphine, HCL , and boron trichloride. The Mak patent neither discloses nor suggests exposing the wafer to a material selected from the group consisting of phosphine, HCL , and boron trichloride. Accordingly, the combination of elements recited in amended claim 76 is allowable.

New claim 85 recites a method of treating a wafer that includes depositing a first conductive layer onto the wafer, exposing the wafer to a reducing environment, depositing a second conductive layer, and passivating the first and second conductive layers by exposing the wafer to a material selected from the group consisting of diborane, phosphine, HCL , and boron trichloride. Mak neither discloses nor suggests passivating the first and second conductive layers by exposing the wafer to a material selected from the group consisting of diborane, phosphine, HCL , and boron trichloride. As previously discussed, in Mak the tungsten nitride barrier layer is not exposed to diborane to passivate the layer, but instead the diborane merely serves as a source

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of boron to remove fluorine from the reaction that takes place during formation of the tungsten layer 9. The combination of elements recited in new claim 85 is therefore allowable.

The claims dependent on the independent claims are allowable for the same reasons as the independent claims, and because of the additional limitations added by the dependent claims.

All pending claims are in condition for allowance, and favorable consideration and a Notice of Allowance are respectfully requested. The Examiner is requested to contact the undersigned at the number listed below for a telephone interview if, upon consideration of this amendment, the Examiner determines any pending claims are not in condition for allowance. The undersigned also requests the Examiner to direct all future correspondence to the address set forth below in the event the Examiner shows a different correspondence address for the attorney of record.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned **"Version with Markings to Show Changes Made"**.

Respectfully submitted,
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PFR:asw

Enclosures:

Postcard

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Fee Transmittal Sheet (+ copy)

Supplemental Information Disclosure Statement (+ copy)

Form PTO-1449

Cited References (6)

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Claims:

Claims 47 and 48 have been cancelled.

Claims 76, 78, and 79 have been amended as follows:

76. (Amended) A method of treating a wafer, comprising:
depositing a first conductive layer onto the wafer;
exposing the wafer in situ to a reducing environment; [and]
depositing a second conductive layer; and
exposing the wafer to a [selection] material selected from the
group consisting of [diborane,] phosphine, [methylsilane, hexamethyldisilane,
hexamethyldisilazane,] HCL, and boron trichloride[, and combinations thereof].

78. (Amended) The method of claim 76 wherein exposing the wafer to a
[selection] material selected from the group consisting of [diborane,] phosphine[, methylsilane,
hexamethyldisilane, hexamethyldisilazane, HCL,] and boron trichloride[, and combinations
thereof] comprises exposing the wafer to this selection prior to exposing the wafer in situ to a
reducing environment.

79. (Amended) The method of claim 76 wherein exposing the wafer to a
[selection] material selected from the group consisting of [diborane,] phosphine[, methylsilane,
hexamethyldisilane, hexamethyldisilazane,] HCL, and boron trichloride[, and combinations
thereof] comprises exposing the wafer to this selection prior to depositing the second conductive
layer.